Energy, Mines and Resources Canada | Énergie, Mines et Ressources Canada

CANMET

Canada Centre for Mineral and Energy Technology | Centre canadien de la technologie des minéraux et de l'énergie

PLAN AND REQUIREMENTS FOR A FIELD EXPERIMENT ON THE USE OF WOOD WASTE FOR ACID MINE-WATER POLLUTION-ABATEMENT

A. Jongejan
Extractive Metallurgy Laboratory

November 1983

APR 5 1984

MICROMEDIA

Project MRP-3.5.0.1.01
Control of Uranium Tailings Effluents

MINERALS RESEARCH PROGRAM
MINERAL SCIENCES LABORATORIES
DIVISION REPORT MRP/MSL 83-144 (TR)

21 pp

This document was produced by scanning the original publication.

Ce document a été produit à partir d'une numérisation de la publication originale.

(CANMET)

l'énergie (CANMET)

PLAN AND REQUIREMENTS FOR A FIELD EXPERIMENT ON THE USE OF WOOD WASTE FOR ACID MINE-WATER POLLUTION-ABATEMENT

by

A. Jongejan

ABSTRACT

Previous laboratory experiments on the practical use of wood waste for acid mine-water pollution-abatement were successful. They had simulated factors in the treatment of acid tailings drainage-water in a ditch with degrading wood waste and the subsequent precipitation of heavy metals in a settling lagoon. By necessity, these experiments had been limited. Abatement of polluted water flowing through along volume of wood waste instead of its simulation by using water circulation must still be determined. Also, the water flow rate control by pH-values in the wood waste and other factors could not be simulated in the laboratory. Extended experiments are, therefore, required to determine the practicality of the process before lengthy work on optimization can be started. Because the shape of most indoor-locations can not accommodate the resources wood waste length, the experiments must be continued in the field.

A plan for the construction of an experimental system, the required monitor and control equipment, and the experiments are presently described. Costs are estimated at $35,000.

PLAN ET EXIGENCES RELATIFS À UNE EXPÉRIENCE IN SITU SUR L'UTILISATION DE RÉSIDUS LIGNEUX POUR DIMINUER LA POLLUTION DES EAUX ACIDES DANS LES MINES

par

A. Jongejan

RÉSUMÉ

Des expériences précédentes en laboratoire sur l'utilisation pratique de résidus ligneux pour diminuer la pollution des eaux acides dans les mines se sont révélées satisfaisantes. Elles ont consisté à simuler certains facteurs dans le traitement des eaux d'écoulement des résidus acides dans un fossé en effectuant la dégradation des résidus ligneux puis la précipitation des métaux lourds dans un bassin de décantation. On s'est trouvé dans l'obligation de limiter ces expériences. Il reste encore à établir la réduction de l'acidité des eaux polluées s'écoulant à travers une masse de résidus ligneux au lieu d'une simulation par circulation d'eau. En outre, il est impossible de simuler en laboratoire le contrôle du débit des eaux au moyen du pH des résidus ligneux, ainsi que d'autres facteurs. Il faut par conséquent effectuer des expériences plus poussées en vue de déterminer l'utilité du procédé avant d'entreprendre des travaux assez longs sur son optimalisation. Il y a lieu de poursuivre les expériences sur le terrain car la plupart des installations intérieures ne peuvent reproduire la longueur réelle des résidus.

Un plan de construction d'un système expérimental, le matérial de surveillance et de contrôle nécessaire et les expériences réalisées vont être décrits. Les coûts se chiffreraient à 35 000 $.

INTRODUCTION

The project on the use of wood waste for acid mine-water pollution-abatement originated in the observation of a natural process. The accidental formation of a dam of degrading wood in an acid mine-water stream appeared to clean up the pollution to a great extent. A microbial process was involved as, apart from the wood degradation, sulphate-reducing micro-organisms were precipitating heavy metals as sulphides. A practical application of the process had to be considered because it abated pollution in natural conditions. Experiments described in an earlier report (1) showed the possibility of simulating the process in laboratory conditions.

Sulphate-reducing bacteria require not only organic nutrients, but also a pH higher than 5 to become active. Both requirements are lacking in acid mine water. Organic nutrients could be expected to be formed by micro-organisms degrading the wood waste. However, the nature of the process producing the required pH-increase was not known.

Although the process was simulated in the laboratory, the nature of the variables that could be controlled in a practical pollution-abatement process had to be determined. A practical process was conceived to be as follows: (a) tailings effluents or mine water would be collected in a reservoir or pond, (b) the water flow rate from this reservoir into a ditch filled with wood waste would be controlled and (c) the wood-waste effluent would flow into a series of lagoons for heavy-metal precipitation.

Factors involved in the process increasing the pH microbially were described previously (2). The information was applied to laboratory experiments on the water treatment method using wood waste in a series of troughs simulating ditch conditions (3). These experiments indicated a possible treatment-capacity of acid effluent from approx 200 acres tailings (similar in sulphide-carbonate ratio of Elliot Lake tailings) in a 50 m long ditch at a flow rate of approx 6 mL/min/cm^2 (residence time 12 h; liquid/solid 0.8).

The laboratory experiments, however, were limited. Although the experiments on the design of the waterflow in the trough assembly were successful, water recirculation had to be used to simulate field conditions because the actual ditch length could not be used.

Furthermore, the experiments indicated that the water flow rate in the ditch had to be controlled according to the pH-values of the water. The position of the (control) pH-electrode in the ditch, and also, the preferable shape of the ditch cross section, baffle spacings and extent of aeration must be determined. Therefore, an experiment using a pH-controlled water flow through a long wood waste volume according to reported results (3) is required to determine the practical applicability of the process. Although it is possible to optimize a few process parameters in the laboratory to a certain extent, obtaining information about the practicality of the process should have priority in view of the lengthy experiments required for factorially- designed optimization experiments (see p. 11). The experiments are, therefore, based on the same economical considerations as those of previous work (3). Controlled experiments in the field are less preferable than indoor experiments in that seasonal conditions cause severe delays (rain, winter). The shape of most indoor-locations, however, can not accommodate the required wood waste length. The design and a cost estimate for such a field experiment are given in the following.

CONSTRUCTION PLAN OF FIELD EXPERIMENT

The plan simulating a tailings area, drainage water reservoir, ditch with wood waste and sulphide settling lagoons is shown in Figure 1. The tailings area consists of a 6-m diameter wooden pond lined with plastic.

The pond is filled approximately 20-30 cm high with 4-6 m^3 tailings provided by 3-4 truck loads. Water is supplied on the tailings by sprayers from one side of the pond. Drainage flows out the opposite side through a piece of plastic pipe into a reservoir constructed of the same material. The tailings pond is provided with a mobile walkway rotating on a pin in a central column, not only for levelling the tailings, but also for specific experimental purposes (see p. 8).

The "ditch" consists of three parallel units having differently-shaped cross-sections of approximately the same size (0.1 m^2). The 40-cm wide trough-type unit may possibly be constructed in the same way as the ponds. PVC-pipe halves may be used for the construction of the other two units. All units contain baffles consisting of two closely-spaced plates. One plate is provided with a screened window at the bottom, the other forms the

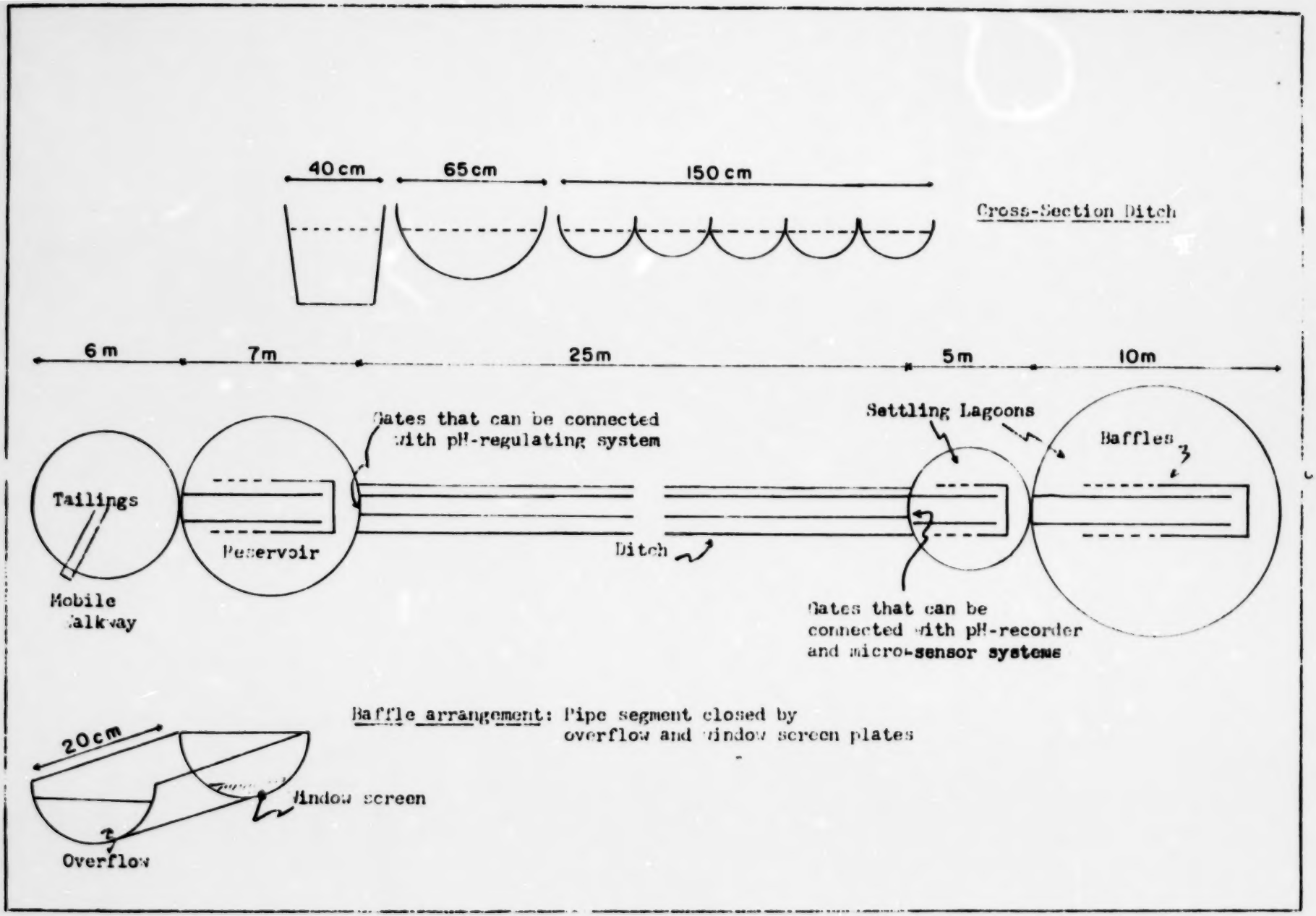

Fig. 1 - Plan of ditch units, baffles and ponds

overflow. The plates are the ends of small units (20 cm long) that can be pressed and fastened with removable rubber cement into the ditch-units at regular intervals according to the results of previous experiments (3). Aeration can be applied between the plates. Perforated sewer-pipe having larger diameter than the outlet pipes disperse the water in the reservoir and lagoons.

Water and electric power supplies, and water disposal will depend on the location where the experiment can be carried out.

MONITOR AND CONTROL EQUIPMENT USED IN THE EXPERIMENT

Monitor and control equipment is not only required for the operation of the process, but also for the experiments that could not be done in laboratory conditions. Only the water flow rate from the reservoir into the ditch must be controlled in an actual operation. Besides the position of the pH-electrode(s) in the ditch controlling the water flow rate, the water supply must be controlled and determined in the experiment. The required equipment in connection with its function in the process is shown in Figure 2.

The water supplied by the sprayers on the tailings is controlled by a water-level sensor in the reservoir. The sensor maintains the level at a certain height above the pipe outlet to the ditch. It opens the water-supply valve when the level goes down due to water flowing out of the reservoir into the ditch, or water loss caused by evaporation. The extent of evaporation is measured by closing the valve to the ditch (manual override) and using a waterflow-accumulation meter with a recorder. This monitor-control loop is, therefore, only a requirement for experimental purposes, e.g. simulating rainfall, etc.

The water flow rate from the reservoir through the ditch is controlled by a valve connected with a unit reacting on the pH-values in a certain location in the ditch. The relationships between the pH-values and ensuing flowrates in this second control loop is given by a curve (Figure 3) estimated and adjusted to fit performance of electronic instruments from information obtained in the lab experiments. (see p. 14.) For determining the position of the control pH-electrode according to the pH(increase)-gradient in the ditch and the water flow rate effects, a series of pH-recorders is used. The distance between the electrodes 25/5 m = 5 m was based on results of experiments (3) indicating that a

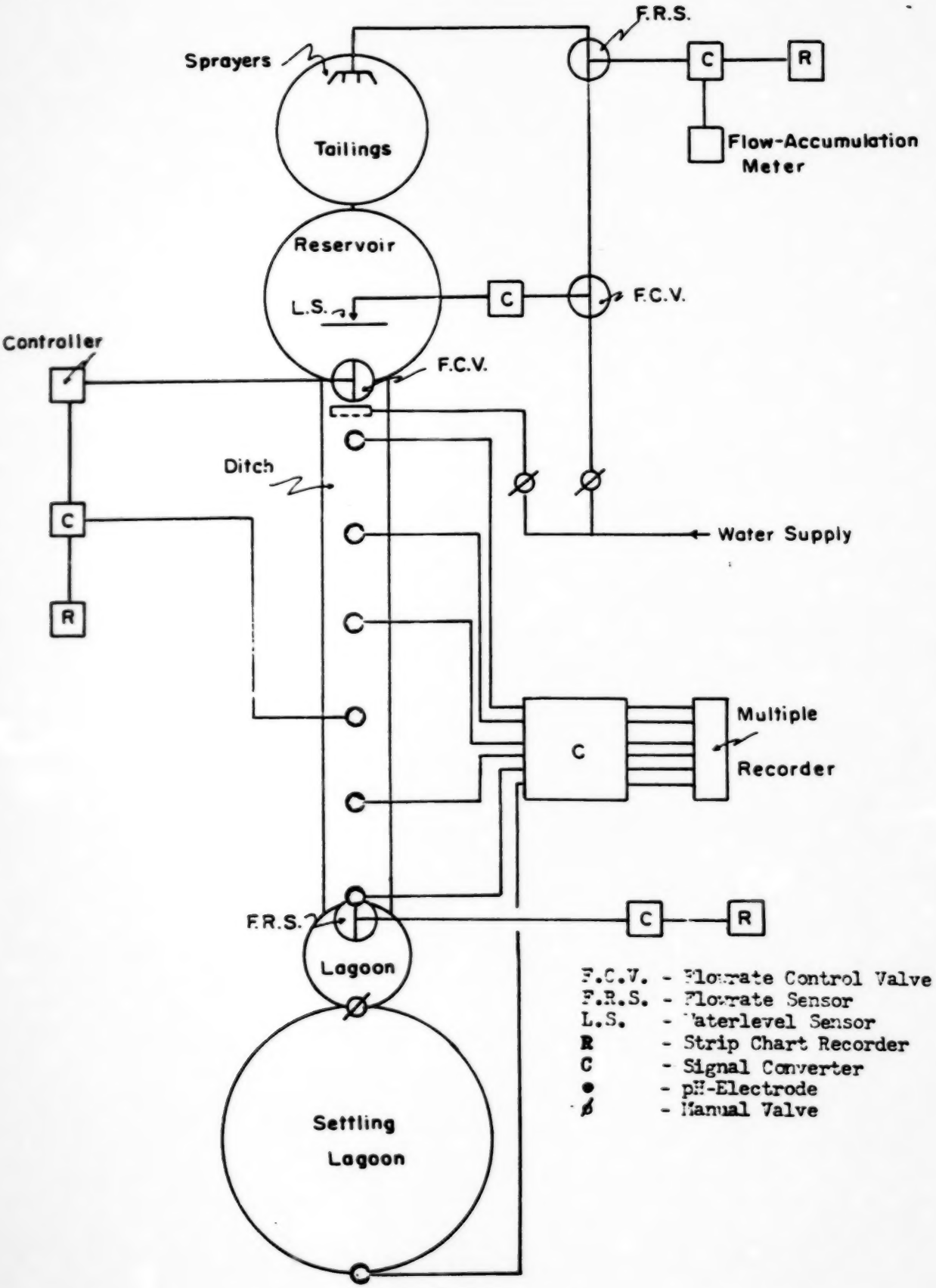

Fig. 2 - Arrangement of monitor and control equipment

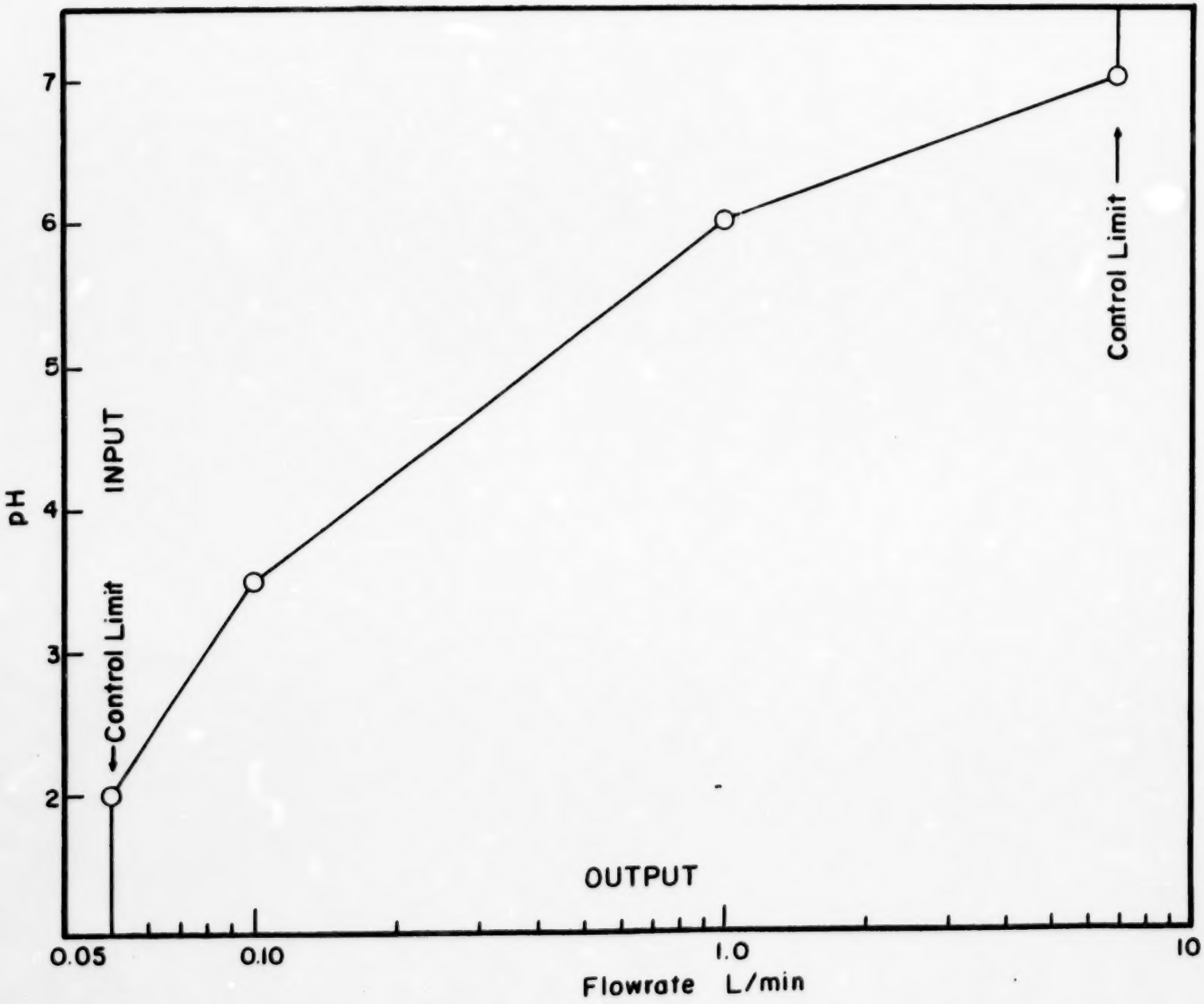

Fig. 3 - Relationship between pH in the ditch and allowable water flow rate from the reservoir

pH-gradient was measurable already at 2.4 m. Once information in this respect has been obtained, only the second control-loop consisting of the flow rate controller, acting according to the pH-values in the ditch and recorder, is used in an actual operation. The flow rate recorder at the lagoon outlet is used to collect information on evaporation and flow delays in the system. The relationships in Figure 3 represent probably a natural condition. After melting of snow or a rainstorm resulting in an increased flow rate, the pH increases (dilution). A drought or decrease in flow rate has the opposite effect. It increases the acidity by concentration as has been observed in field observations.

PLANNED EXPERIMENTS

1. After construction of the field arrangement the operation of the monitor and control equipment is tested. Various parts of this equipment have been tested and calibrated in the laboratory before the construction. The flow rates through the pH-controlled valve at certain function-settings of the controller should be measured for further calibration. The same should be done for the water-supply flow rates by the water level sensor. The flow rate meters should also be pre-calibrated in the laboratory before field application. A Signet flowmeter is probably satisfactory for measuring the water supply flowrate because the water is clear and under pressure. This becomes doubtful for the flow rate measurement at the end of the ditch. A more satisfactory method may have to be designed, e.g. a weir containing a hinged blade in connection with a pressure transducer (Gould Inc.). This work should, therefore, be done before the construction of the pond-ditch arrangement because the details of the control-monitoring system have to be included in the construction specifications. It can be expected to require a significant amount of time. This work can not be contracted out because it depends on process requirements. Certain simplifications in view of technical practicality can or cannot be allowed.

(a) The tailings pond and reservoir are filled with water which should be stopped at a certain level by the level-control (pH-controlled valve closed). The total volume of pond and reservoir is measured by the waterflow-accumulation meter. Evaporation rate and volume will be measured and monitored. This will depend on climatic conditions which must be

recorded during the length of the experiment. Evaporation of exposed water will be compared with that of water included in tailings (see 4).

(b) The opening and closing of the pH-controlled valve will be tested by immersing the electrode in water having a pH adjusted to different values with 10% (v/v) H_2SO_4.

(c) The pH-recorders, and ditch-effluent flow rate recorder will be checked and calibrated using a 1 to 2 L/min flowrate from the reservoir.

2. Tailings are supplied to the pond, levelled, soaked and filled with water (pH-controlled valve closed).

3. Before starting the experiments with wood waste, information will be obtained on the effect on the pH-gradients in a tailings developed by inserting a cylindrical nylon-mesh bag (augerhole) filled with limestone having a particular grain-size mix (4). pH-measurements will be done along a grid over the tailings using e.g. 50 mL/min and 2 L/min flow rates (pH-controlled valve opened by manual override). The walkway over the pond will be used for these pH-measurements, the placing and removing of the limestone. Pollution from comparatively low-sulphide tailings may be abated by filling a grid of augerholes in the tailings with limestone. The measurements in the experiment would provide information about the feasibility of this method.

4. The limestone is removed, water affected by the limestone flushed out, reservoir emptied and pH-controlled valve closed. The evaporation rate with tailings in the pond will be determined in the same way as under 1(a). The water is drained out of the system after the determination.

5. The water in the ditch and lagoons is also flushed out with fresh water entering the ditch at the reservoir exit gate.

6. Waste cardboard and paper is shredded (W.W. shredder). Wood waste (sawdust from mill) is supplied, mixed with the paper waste and placed in one of the ditch units (preferably the trough-type unit)).

7. A nutrient solution is prepared by mixing a 10x concentrate with e.g. 500 L water in reservoir. Valve is opened for a soak and flow through the wood waste mix. Another volume (10,000 L) is prepared sufficient for two weeks flow (e.g. 200-460 mL/min) requiring water in the reservoir at least 25 cm above the outlet. It is possible to use a tank for this purpose which may improve and facilitate the mixing.

8. Large volumes (e.g. 50 L tanks) of cultures of pH-increasing and cellulolytic bacteria, and fungi are grown from concentrates prepared in the lab.

9. The pH-increasing, cellulolytic bacteria and fungi are pumped consecutively in the system at the reservoir outlet and flushed two weeks through the wood waste using a low (200-460 mL/min; see 7) flow rate of the nutrient solution. Formation of anaerobic conditions is prevented by aeration between the baffle plates.

10. The slowest flow rate is determined that still does not create anaerobic conditions. Nutrient solution sufficient for 7 days (5000 L; see 11) is prepared in a tank to be pumped into the ditch taking over the supply that is being exhausted in the reservoir. To save costs of a tank arrangement, it may be possible to dilute a nutrient solution in the reservoir gradually using a line connected with the sprayer supply (Not shown in Fig. 2). Supply from a tank is preferable.

11. The reservoir is filled with fresh water, and by opening the pH-controlled valve gradually (manually), the nutrient solution supplied from a tank is diluted and replaced with fresh water.

12. A similar mixing of fresh water with tailings drainage water is used to adapt the microbial population to the polluted conditions. Flow from the tailings and reservoir is controlled manually until the reservoir is filled with tailings drainage water. This mixing is controlled by observations of pH and microbial activity (samples checked for growth), and can not be detailed quantitatively before the actual experiment.

13. Seepage of tailings drainage water at the lowest flow rate (See 10) is maintained for e.g. one or two weeks; the pH-gradient is measured and should be representative for the particular flow rate; distribution of dissolved oxygen and heavy metals will be determined; conductivity of the water at the lagoon can be monitored and sulphide content determined.

14. The effect of increased aeration on the pH-gradient and other variables will be determined.

15. The flow rate will be increased and measurements repeated after one week. This procedure will be repeated until the pH of the wood waste effluent drops below 5. This determines the maximum flow rate. The project may stop here when the flow rate appears too low to be practically useful or the flow rate exceeds the maximum through the wood waste. A larger grain-size can be tried in that case, because the limitations of the process are more in the flow rate through the wood than in the bacterial action according to previous lab experiments. If favourable results are obtained, the project from this stage on can become a "demonstration project".

16. From the results of manually stepwise-increasing the flow rate and determining the effects on the pH-increase gradient, the position of the pH-electrode controlling the flow rate should be determined (arbitrarily placed at 15 m in Figure 2)

17. Another batch of wood waste mix is prepared during the determination of the maximum flow rate, and 10% used-waste is mixed in after terminating the experiment (see 16). It is placed in the second ditch unit (65 cm wide sewer pipe-half).

18. Procedures are repeated to obtain information on the preferable shape of the cross-section of the ditch, including the third ditch-unit consisting of five narrower pipe-halves (150 cm wide total). The ditch depth is decreased from the first to the third unit, and possible "channelling" in the wood is reduced by the use of a number of narrow pipes. However, the oxygen content in these conditions may become too high for the process to take place (3), and the most preferable cross-section

shape must be determined.

19. Although the procedures to be followed at the beginning of the experiment could be outlined in general, continuation depends on the results. Even the above experiments require constant attention and adjustments of variables that can not be predicted. Not being optimized, the process does not have stable equilibrium conditions. Information should be obtained on the maximum flowrate that still produces a pH 5 wood waste effluent. If this result looks promising, the position of the pH-electrode for flow rate control should be determined, and also the preferable shape of the ditch cross-section and baffle spacing. The progress of the experiments will be monitored and changes made to the parameters as and when required as in previous work (3). The change of wood waste, growing fresh microbial cultures with the change of each variable would require a very long time to obtain information about the practical use of the process.

20. However, if the practicality has been established and the most preferable values of the principal variables have been determined, optimization projects can begin as follows:

(a) Analysis of the microbial population at specific locations in the wood waste along the ditch, e.g. 1 m from the reservoir, in the center and near the ditch-outlet, same of the population of the lagoons and a comparison of the results of these analyses with the species that had been introduced (see 8). Improvement of microbial composition can result.

(b) The possibility to use species such as Chlorobium, Thiosarcina or Thiospirillum to decrease the soluble sulphide content of the settling lagoon's effluent.

(c) The toxic effects of commonly-used materials such as soaps, detergents, grease or oils, gasoline, etc. on the pH-increasing and cellulolytic action of the microbial population should be determined, and subsequently, a possible improvement of any detrimental effect tried out by introducing species acting specifically on these materials, e.g. nocardias on hydrocarbons, etc.

(d) Instead of sawdust, coarser grain sizes, e.g. woodchips, allowing a faster flow rate, but probably lower microbial action should be tried out.

(e) Study of particular synecological relationships between carefully selected species under (a) should be made. Otherwise, an infinite amount of time can be spent on this subject.

Generally, once the practical usefulness of the process has been established, a great deal of time can be spent on improving and optimizing various aspects. However, during this period it should serve as a demonstration for the mining industry. Those interested can come and see the process in action; design and experiment in their own locality; return to the CANMET-experiment for further discussion, etc. This type of development is widely used in agriculture, e.g. the composting facility in Durham, N.H. was developed and based on U.S. Agriculture's project in Beltsville, Md.

COST ESTIMATES

The costs for the construction and servicing will depend much on the location where the experiment can be carried out. The extension of water and electical supplies may vary from 100 m to a requirement of well drilling and a generator. A 300-m extension is taken as example. This will require $1400 - using industrial waterpipe above ground, while the costs for the electrical supply can vary between $1000 and $3000 depending on the requirement to lay underground cable, the length of time it will be used, etc. according to T.S.D. estimators. Because of the lack of specifications about locality, time, etc. these cost estimates could not be compared with those of commercial enterprises. The water pressure does not need to be high as the water flow rates through the wood waste depend on control of flow from the reservoir and this can be filled up at any flow rate. Similarly, the electrical requirements are not excessive as the measuring span of the instruments is 4-20 mA or 1-5V, and they can be run optionally on batteries in field-use. However, if pneumatic valves are selected, an air compressor may be required. Furthermore, it is possible that water and electric power have to be connected with a mobile prep-room. For the sake of cost estimating an average of $2000 is assumed.

The construction of the tailings pond and reservoir would be facilitated by a sloping terrain. For instance, a flowrate of 6 L/min or 8640 L/day will require a water level height of 22.5-cm above the reservoir outlet pipe. If the pH has not decreased at lower flow rates and the maximum flow rate equals that through the wood waste (e.g. 6 L/min), this maximum flow rate must be used, at least, three days for establishing equilibrium conditions and measurements in the experiments. It would require a 67.5-cm water level above the reservoir outlet. If the terrain is sloping, the reservoir outlet does not need to be a significant distance above ground level. However, if the terrain is almost level, a 4-ft high reservoir wall (using sections of 4 x 8-ft plywood panels or wafer board against 2 x 4-in. studs) may not be sufficient to provide ditch depth and slope required in the process. The structure must be raised, and will cost more. If the terrain is rocky, stud construction may have to be more elaborate than on a soil allowing the use of posts, also increasing costs.

The assumption is made that $\frac{1}{2}$ in. waferboard may be used. However, costs for unfinished, waterproof plywood are also given.

The use of PVC pipe-halves shown in Figure 1, would be preferable over that of plastic sheeting supported by wood because of increased rigidity, sturdiness and ease of construction. If the use of plastic sheeting is extended to the two ditch units formed by sewer-pipe halves, the multiple unit would consist of four (instead of 5) 20 x 20-cm (15 cm bottom) channels beside the 40 x 40-cm (30 cm bottom) trough. Both units would be supported by 4 x 8-ft plywood panels, while the 65 cm unit would become a 30 x 50-cm (45 cm bottom) trough supported by 2 x 8-ft panels.

The type of plastic used depends on the extent it will be exposed to abuse. The bottom of the ponds can be covered with a thin sheet which in turn, is covered with a layer of soil eliminating any abuse. The ditch units have to withstand heavier abuse and have to use thicker material. The use of PVC pipe-halves could increase the costs approximately $2000.

The water-supply loop in the monitor-control equipment consists simply of a level sensor controlling the opening of a valve. The selection of the sensor was based on a preferance for ultrasonic resonance over mechanical devices using floats. A direct-acting ball-float (toilet-type mechanism) would reduce costs, but lacks accuracy and its performance in acid mine-water is questionable. All mechanical devices require pipe connections inside the reservoir, while the ultrasonic sensor can measure the level

from a distance and produce an electric signal. This can act also on a solenoid valve via an electronic relay instead of the pneumatic control. This type of control, however, may produce temporary water surges that may run over instead of through the tailings, while the cost difference is only a few hundred dollars lower.

The loop controlling the water flow rate in the ditch is more complicated electronically. Conditions shown in Fig. 3 were inferred from the results of the lab experiments (a non-linear log-relationship), but are expensive to achieve electronically. They were, therefore, further simplified.

The costs for monitoring the pH-gradient in the ditch using six pH-electrodes varies considerably also depending on the types of pH-electrodes used (e.g. Signet submersible electrode-assemblies, ea. $220), and the possibility to convert an available recorder to be connected with an automatic multiple signal-conversion switch (e.g. Six-channel automatic switch, model SAS_2, Bach Simpson Ltd.).

The feasibility to mix nutrient solutions (See 7 and 10, p. 9) in the reservoir is questionable because of its comparatively shallow depth. The diameter of the reservoir is given arbitrarily as 7 m particularly in view of costs. However, a diameter of 12.5 m would be preferable in view of water volume available for the experiments. This is, however, a size that would be more shallow for mixing. The use of a polyethylene tank for mixing would be preferable. However, costs including a mixer (Nortec S.G.S. Inc., Montreal; 1000 gal Canbar C-122 tank with Lightnin mixer) would be increased by $3000 which would be justified if the tank could be used in other projects. The preferable increase in diameter of the reservoir is connected with the decrease in waterhead using flowrates higher than 1 L/min. A decrease in waterhead results in a decrease of water pressure in the pH-controlled valve. Therefore, a decrease in flowrate for a certain valve opening indicated by the pH-valve in the ditch. However, it should be possible to adjust the pH-valve opening control taking decrease in water pressure into account.

If a room in a building nearby is available to serve as office and preparation room, costs will be reduced $1980/a plus that for water and electrical connection. The availability of a prep room ($1980), the probability of reducing the water and power extension costs by $2000 and the possibility of using a ball-float valve (-$2900 + $350 = $2550) would

reduce the total direct costs to $28,854. However, a requirement to use ¼-in. plywood (+$2125 - $744 = + $1380), two 3-pen recorders (=$4800) and a mixing tank (+$3000) will raise the costs to $44,564. These estimates are, therefore, merely indicative of the cost range of the experiment averaging approximately $35000. Because the selection of construction materials and monitor-control equipment was made from limited information, it can undoubtedly be improved concerning the performance-costs balance, possibly in the order of 10%. Furthermore, the costs of the ponds-ditch arrangement are also preliminary and based on general information obtained from T.S.D. and above-ground swimming-pool producers. Costs for contracting this work out must be added. The design of the experiments and the requirements for the monitor-control equipment, however, could be projected more accurately.

1. Supply of water and electric power (e.g. 300 m extension, resp. $1400 - and $2000) $3400

2. Site survey for construction of ponds and ditch units $ 250

3. Site preparation and construction of 6-m, 7-m, 5-m and 10-m diam ponds and 25 m long ditch-units made out of plastic sheeting supported by wooden frames.

a. Materials: 85 ½" 4x8-ft waferboard panels at $8.75 $ 744

or ¾" plywood panels at $25 - (Zagerman Co. Ottawa, Ont.) $2125

450 8-ft (2x4-in.) lumber, at $2.50 p.p. (Beaver Lumber Co.) $1125

4300 sq ft plastic sheeting (Kentain Products Ltd., Kitchener, Ont.)

1470 sq ft, 12 mil PVC for 7-m, 5-m and 10-m bottoms $1250

1094 sq ft, 20 mil PVC for sides of same $1210

448 sq ft, 20 and 40 mil PVC for tailings pond $ 672

1312 sq ft, 40 mil PVC for 3 ditch units $5248

Miscellaneous: sprayers, pipe for connections, baffles inside ponds, aeration, etc. $ 350

b. Labour: 140 h x $22 - (CANMET carpenters) $3080

4. Monitor and control equipment

a. Waterlevel sensor, model no. SPP-10 Soget Inc. (Nortec S.G.S. Montreal) $1400

Pneumo-electric transducer, no. 546, Fisher Controls Ltd. (Laurentide Controls Ltd., Montreal)

and

Ball-valve, V100 with 1052 actuator; same $1500

Or; direct-acting ball-float valve, no. 171 F $ 350

b. Micro-flow sensor, 25 mL - 6 L/min; Signet Scientific Co., MK 505-3 $ 550

Recorder, RD 222, Fisher Controls; see below (e)
Totalizing unit, LS 126; same $1000
or Signet Scientific Co., MK 575 $ 550

c. pH-electrode; VL 5993-50, VL 5993-51; Signet Scientific Co. (Horizon Environmental or Brian Engineering, Montreal).		$ 220
Signal converter (See below 'd')		
Controller, Fisher and Porter, 53 MC1111 (Montreal)		$ 2080
Recorder, RD 222; same. See below (e)		
Ball-valve, V100 with 1052 actuator, same and pneumo-electric transducer, 546; same		$ 1500
d. 6 pH-electrodes, submersible (Signet Scientific Co. each $220		$ 1320
Six-channel automatic switch, SAS2, (Bach Simpson Ltd.)		$ 1825
Recorders, 2 x RD 222, 3-pen, Fisher Controls Ltd.	$4800.-	
or available (1950) L. & N. dotted-line recorder to be converted		$ 300
e. Micro-flow sensor, MK 505-3; Signet Scientific Co. (Probably a weir with Gould pressure transducer preferable)		$ 550
Recorder, RD 222, 3-pen, Fisher Controls Ltd.		$ 2400
5. Office, preparation and control room (National Rental Ltd., Ottawa, mobile unit, 160 sq ft/year)		$ 1980
6. Miscellaneous:		
Tailings 3 or 4 truck loads, (Elliot Lake or other mine)		$ 1000
Wood waste from saw mill (transportation)		$ 150
Variable-flow pump, 0-5 gpm; CP 7100-31		$ 350
Air compressor for aeration and pneumatic valves Cdn. Tire.; ¼ hp, 49-2561		$ 380
Subtotal		$35384
10% Contingency		$ 3550
Total		$38934

REFERENCES

1. Jongejan, A. and Wilkins, A.L. "Progress report on the study of the action of cellulose decomposers on the viability of sulphate-reducing micro-organisms"; Division Report MRP/MSL 78-58 (TR); CANMET, Energy, Mines and Resources Canada; 1978.

2. Jongejan, A. "Observations on the microbial cellulose degradation process that decreases water acidity"; Division Report MRP/MSL 84-32 (TR); CANMET, Energy, Mines and Resources Canada; 1982.

3. Jongejan, A. "Progress report on the use of wood waste for acid mine-water pollution abatement"; Division Report MRP/MSL 83-116 (IR); CANMET, Energy, Mines and Resources Canada; 1983.

4. Jongejan, A. "Physical and chemical aspects of the weathering of pyrite-carbonate mixtures in view of water pollution from tailings areas"; Division Report MRP/MSL 75-185 (R); CANMET, Energy, Mines and Resources Canada; 1975.

POOR

QUALITY

ORIGINAL